

No. 1. — *Contributions from the Petrographical Laboratory of the Harvard University Museum, in Charge of J. E. WOLFF.*

I.

On the Petrographical Characters of a Dike of Diabase in the Boston Basin. By WILLIAM H. HOBBS.

IN the region north of Boston occurs a most interesting series of massive rocks, which break through the slates and sandstones, and include granite, quartz-porphry, quartzless-porphry, elæolite-syenite, diorite, porphyrite, diabase, augite-porphryrite, and gabbro. They have been studied in greater or less detail by many observers, prominent among whom are W. O. Crosby, M. E. Wadsworth, and J. S. Diller.

The rocks which have afforded material for the present study belong to a single dike, and may be seen in a series of exposures in Medford and Somerville. They are coarsely crystalline rocks, and have borne the names "syenite" and "diorite." They have in general been carefully distinguished from similar rocks of finer texture known as "greenstones," which were shown by Wadsworth in 1877 to have about the same composition as the coarser rock, and were considered by him as identical with it. The finely crystalline rock seems to be more widely distributed than the coarse variety. In the present paper it has been studied only at a few localities, where there was some promise of deciphering its relations with the "diorite."

The age of these rocks has not been accurately determined, though they have generally been considered post-triassic on account of their lithological resemblance to the diabase of the Connecticut Valley. The slates through which they have broken are probably identical with the Lower Cambrian argillite of Braintree. Diller has furnished evidence to show that the finely crystalline diabase ("greenstone") is the youngest of the eruptives of this region, its dikes cutting those of the other rocks.¹

Many mistakes have been made in determining the composition of both the so-called "diorite" and "greenstone." The "diorite" was long

¹ Bull. Mus. Comp. Zoöl. at Harvard College, VII. 179.

ago described from the Granite Street locality in Somerville by J. F. and S. L. Dana,¹ and by J. W. Webster,² as made up essentially of the minerals feldspar and hornblende. This was supported by Professor Hitchcock, in his Survey of Massachusetts.³ The mistake, which consisted in taking augite to be hornblende, was further repeated by W. W. Dodge⁴ and W. O. Crosby.⁵ Professor Wadsworth⁶ was the first to apply the microscope to the study of this region, and was enabled to determine correctly the general composition of the rocks. His study included all the eruptives exposed in Somerville, and part of those outcropping in Medford, Malden, Brighton, and Brookline. He pointed out the connection of the outcrops, and indicated their general trend. He showed that the feldspar is plagioclase, and that the prevailing non-feldspathic constituent is augite. On the basis of an observed identity in mineral composition he concluded that the fine-grained "greenstone" is identical with the coarser "diorite." Professor Crosby, in his "Contributions to the Geology of Eastern Massachusetts,"⁷ has quite accurately outlined on his map the area in which these rocks are exposed.

The present article, being restricted mainly to the coarsely crystalline diabase, repeats to some extent the work of Professor Wadsworth. While the results are in the main confirmatory, there are still important points of difference, and some new facts have been determined.

Leaving out of consideration the vicinity of the Old Powder House in Somerville, the field study has yielded but little. The attempt has been mainly to add something to our knowledge of the petrographical characters of the so-called "Mesozoic diabase of the Atlantic border." Those who desire a full literature of the subject treated in this paper should refer to the above-cited work of Professor Wadsworth.

Field Notes.

The dike of diabase which is here considered extends from Granite Street in Somerville to Spot Pond in Stoneham, and probably beyond, although no examination in the field was carried beyond that point.

¹ Memoirs Amer. Acad., 1st series, IV. 163 (1818).

² Boston Jour. Phil. and Arts, II. 282 (1824).

³ Final Rep. Geol. of Massachusetts, 640-663 (1841).

⁴ Proc. Boston Soc. Nat. Hist., XVII. 415 (1875).

⁵ Occasional Papers of Boston Soc. Nat. Hist., Vol. III.

⁶ Notes on the Petrography of Boston and Vicinity, by M. E. Wadsworth. Proc. Boston Soc. Nat. Hist., XIX. 217 (1877).

⁷ Occasional Papers of Boston Soc. Nat. Hist., Vol. III.

No outcrops of the coarse rock have been found south of the Granite Street quarry. Professor Crosby has included the fine-grained diabase which crops out at the Pumping Station in Brighton, and similar rocks in Brookline and Newton, as a part of this dike; but the great change of strike required, and the long intervening distance without exposures, are opposed to the supposition. From the Granite Street quarries to the Old Powder House in Somerville, (a distance of about one and a half miles,) the strike of the exposures is N. 25° W. From that point to Spot Pond, the trend is N. 10° E. In Medford and Somerville the country rock is argillite, which has been thrown into gentle folds, the dips of which seldom exceed 35°. A notable exception to this statement is seen at the old slate quarry on Professor's Row, College Hill, where beds strike \pm N. 95° E. and dip \pm 72° to the south. The area of coarse diabase, which has an average width of about two thousand feet, is never found in contact with the slate. The exposures of diabase almost invariably show the well-known weathering to boulders *in situ*, though this is best observed at Pine Hill. North of High Street in Medford the areal geology is complicated by the occurrence of granite and felsite, for the mapping of which very detailed field-work will be necessary.

The arrangement of exposures of coarse and fine grained diabase in the vicinity of the Old Powder House seems to show a gradual passing of one rock into the other. In the immediate vicinity of the Powder House is an extensive outcrop of coarse rock, like that at the Granite Street quarries and Pine Hill. About four hundred feet northeast of the Powder House on Harvard Street the texture is much finer, though not sufficiently fine to be ranked with the normal "greenstone." About six hundred feet S. 20° W. of the Powder House the rock is somewhat finer than at the last-mentioned locality. Again, at the corner of Elm and Morrison Streets, which is about one thousand feet west-southwest of the Powder House, the normal "greenstone" occurs in slate. Moreover, on Willow Avenue, about fifteen hundred feet along the strike to the south from the Harvard Street locality, the rock is practically identical with that at the latter place. From this it seems probable that the coarsely crystalline rock at the Powder House is near the middle of the dike, where the cooling was slow, and that the gradual diminution in the size of the grains in going from that point is owing to more rapid cooling near the contact.

The wide distribution of the "greenstone" has made it impracticable for me to make a complete examination of it, but the few localities which

have here been studied agree so well with each other, and with Professor Wadsworth's notes on the other localities where the same rock is exposed, that a complete study of it seems unnecessary to prove its identity with the "diorite."

Petrographical Notes.

Having shown by field observations that the so-called "diorite" is equivalent to the so-called "greenstone," the rocks will be distinguished according to their mineral composition, without regard to coarseness of texture. Microscopic examination shows the rock to be either a diabase or diorite. The diabase is the principal rock, being found at the quarries on Granite Street (Nos. 207, 209, 209 a, 214), and at the very extensive quarries on Pine Hill (No. 222). The exposure on Harvard Street in Somerville is also of this rock (No. 210). The diorite forms a facies of the diabase, and includes all the outcrops in the vicinity of the Old Powder House (Nos. 208, 216, 218) except No. 210, already mentioned as belonging to the diabase, and the hill north of High Street and east of Highland Avenue (No. 203). Aside from the amphiboloid mineral, the two rocks appear to be almost identical.

Diabase. — This rock is quite uniform in character, and occupies a large part of the area of the dike. A macroscopic examination shows that it is composed mainly of a plagioclase feldspar, and an amphiboloid mineral with more or less biotite and pyrite. The proportions of these minerals vary considerably, causing the specific gravity to range from 2.98 to 2.65. In weathering, the amphiboloid mineral is first decomposed, causing a complete disintegration of the rock to a coarse feldspathic sand. The rock does not show the slightest evidence of lamination, and the feldspars, which have been little interfered with in crystallizing, illustrate well the *divergent strahlig-körnig* arrangement of Lossen, the remaining space being largely occupied by hypidiomorphous crystals of augite. The feldspar grains are more or less lath-shaped; of a white, pink, or green color; generally striated; and have an average length of about 8 mm. The specific gravity of cleavage pieces from No. 222 was found to be 2.638 and 2.643 by determinations with the Thoulet solution, though these results are probably much affected by an incipient alteration. In a single specimen (No. 214), the cleavage of the amphiboloid mineral is so well developed that the mineral can be identified as augite in the hand specimen.

Under the microscope, feldspar and augite are found to be always

present. The feldspar is shown by twinning striations to be plagioclase, which exhibits when fresh beautiful zonal phenomena. In a number of sections the method of Professor Pumpelly¹ or M. Michel Lévy² was applied for the determination of this feldspar. As is well known, this method consists simply in a determination of the maximum extinction angle in the zone of the macro-pinacoid and base, sections which are in this zone being characterized by symmetrical positions of extinction in the two sets of twins, with reference to the twinning plane. Results were obtained as high as 27° , requiring the presence of a feldspar as basic as labradorite. In the classical work of Pumpelly above cited, crystals of feldspar from the Granite Street locality were determined by this method, combined with a modification of Des Cloiseaux's method for determining the size of the basal extinction angle. The highest result obtained by the first method was 16° , and by the second 3° to 4° , though, owing to the sections being inclined to the base, the latter results were more or less unreliable. He concluded that the feldspar was probably albite or oligoclase.

Mechanical separations of the constituent minerals have been made in a number of cases by the Thoulet solution. In every case feldspar was removed with each separation between the specific gravity limits 2.76 and 2.6, and often a considerable portion came below the inferior limit. The grains were found to be seldom pure, and the wide range in specific gravity is doubtless, in part, to be referred to decomposition products. The portion separated below the limit 2.6 was in several cases subjected to microchemical tests by both Boricky's³ and Behrens's⁴ methods, after careful washing to remove all iodide of potassium. Potassium as well as calcium being always detected in this powder, that derived from No. 222 was subjected to quantitative chemical determination, which yielded 4.16% of oxide of potassium. The products of alteration of the feldspar are calcite, and a mineral which is probably kaolin. Considerable green chlorite-like material is often contained in the feldspar grains; but it has apparently been derived from the biotite or augite by alteration, and has found the way to its present position in the feldspar through the cleavage cracks. This substance is the viridite of Professor Wadsworth, which he considered an incipient alteration of the feldspar.

¹ Metasomatic Development of the Copper-bearing Rocks of Lake Superior. Proc. Am. Acad., XIII. 253.

² Minéralogie Micrographique, p. 227.

³ Archiv der Naturw. Landesdurchforschung von Böhmen, III. Band, 5 Abth., Prag, 1877.

⁴ Mikrochemische Methoden zur Mineral Analyse, Amsterdam, 1881.

From what has now been said, it seems certain that a feldspar as basic as labradorite exists in the rock. This is attested both by the high extinction angles in the zone of oP and $\infty P\overline{\infty}$, as well as by the presence of calcite as a significant product of alteration. That a feldspar less basic than oligoclase, and probably as acid, is present also, is shown by the zonal structure and wide range in specific gravity. The potassium obtained from No. 222 may be derived either from alteration products (muscovite?) or from the feldspar itself. The analysis of this rock *in toto*, which may be found in the sequel, shows by the small amount of hydration that little alteration has taken place. It therefore seems to be certain that the potassium is derived from the feldspar itself, either from orthoclase or from a potash plagioclase.

The principal non-feldspathic constituent is augite, which is much broken up by feldspar crystals, though rarely the feldspar is penetrated by augite, showing the nearly contemporaneous formation of the two minerals. The augite, which has generally a rose color, displays a faint dichroism, the ray parallel to b being pink, and that parallel to a pinkish yellow. Both prismatic cleavages are generally well developed, and intersect on the basal plane with the pyroxene angle 87° . Parting parallel to $\infty P\overline{\infty}$ and occasional twins according to the same plane, though not constant features, are observed in the rock from some localities. Zonal structure is not uncommon, and rarely the *hour-glass* structure is well developed. The principal alteration is to uralite, which is found in rims completely surrounding many grains, while with others it has gone farther, and found its way to the centre along the cleavage cracks. This mineral occurs in its usual form in scales or sheaves, and is easily distinguished by its high double refraction, small extinction angle, and strong pleochroism, the ray vibrating parallel to the long axis being dark green, while that vibrating perpendicular to this direction is either green or bright yellow. It is probable that the uralite further changes to chlorite; but since biotite was generally to be found in the vicinity passing into chlorite, it could not be definitely determined. The distribution of the calcite shows that it is derived from the pseudomorphism of the augite, as well as from the decomposition of the feldspar.

Compact green and brown (basaltic) hornblende, though noticed once or twice, are extremely rare.

The biotite when present is generally either in plates, from its penetration of feldspar and augite, clearly original, or in fine scales or aggregate masses in association with augite. The former variety contains inclusions too small to be determined, with the characteristic pleochroic zones

about them. Both varieties have suffered alteration to the ordinary product, chlorite.

Professor Wadsworth considered the biotite secondary to the augite, chlorite being an intermediate stage in the process of alteration. It seems, however, much more probable that this form of the biotite, if indeed secondary, is derived directly from the augite, and that the further alteration of biotite to chlorite sufficiently explains the occurrence of the latter between biotite and augite. The occurrence of biotite as a pseudomorph after augite has been described by Blum,¹ Richthofen,² Tschermak,³ Rohrbach,⁴ and Brauns.⁵ On chemical grounds, without assuming a high degree of metamorphism, the change from chlorite to biotite is difficult to conceive. In some sections, particularly No. 207, a large part of the chlorite can be referred to the diabantite of Hawes.⁶ In many slides chlorite occurs in clearly defined hexagonal sections surrounded by one, or more frequently four or five, concentric rims of magnetite. In other cases biotite can be seen in these basal sections in the act of changing to chlorite, the centre of the crystal being biotite, about which is a wide or narrow rim of chlorite. Figure 1 is taken from sections No. 202 and No. 203, and shows the different stages in this process of pseudomorphism.

Apatite is found as a constant constituent, in unusually large clear crystals, cutting all other minerals. A very small amount of quartz is present, which, in some cases at least, is of secondary origin. Pyrite, magnetite, and ilmenite are present in varying amounts. Magnetite is either in hexagonal sections or more or less irregular masses. These masses are often elongated parallel to blades of chlorite, and are then evidence of secondary origin. A case of this kind is shown in Figure 2. Ilmenite appears in sections, generally hexagonal, like the magnetite, but is easily distinguished by its change to leucoxene or titanite. In a section from the Granite Street quarries (No. 207) this change has been complete and the only vestiges of ilmenite are the masses of white, more or less opaque, highly refracting leucoxene. In other specimens (Nos. 202, 208, 209 a) the decomposition has been less complete, but has taken place in bands, which have three directions parallel to the sides of the rhom-

¹ Pseudomorphosen, I Nachtrag, p. 30; III Nachtrag, p. 93.

² Wien Akad., XXVII. 335. Blum, Pseudomorphosen, III. 96.

³ Porphyrgesteine Oesterreichs, Wien, 1869.

⁴ Min. u. petr. Mitth., VII. 27.

⁵ Neues Jahrbuch, V Beilage Bd., 275.

⁶ Mineralogy and Lithology of New Hampshire, p. 120.

bohedral sections. (See Figure 2.) This structure has been described by many observers and figured by De la Vallée Poussin and Renard,¹ and by Teall.² The structure has been explained by Teall as due to intergrowths of magnetite and ilmenite, according to the fundamental rhombohedron. Since the *Gleitfläche* of ilmenite is R, which is also the normal-solution plane,³ these may be due to decomposition along the normal-solution plane. From No. 222 the heavy portion separated in the Thoulet solution was subjected to treatment with the electro-magnet. Material was thus obtained so magnetic that, when removed from the poles, the grains clung to each other like magnetized iron filings. Treated with concentrated hydrochloric acid, this material was strongly attacked, but did not entirely dissolve even by continued digestion.

Professor Wadsworth has described the occurrence of prehnite as a common product of the alteration of the feldspar and augite. This mineral occurs in veins at the Granite Street quarries, and to determine its characters a section was made from the mineral obtained from one of these veins. The columnar crystals by macroscopic examination seem to have their vertical axes, in general, perpendicular to the walls of the fissure. In the slide, sections parallel to the long axis (*c*) always showed a sheaf-like grouping of individuals having perfect cleavage, both parallel and perpendicular to the vertical axis. These sections afforded no interference figure. Another series of sections (basal) had nearly equal dimensions, with two equally perfect cleavages (∞ P) cutting each other at about 100°. These sections gave also, in converging polarized light, a very perfect biaxial interference figure, with high positive double refraction and orthorhombic dispersion. The optic angle when measured in air was found to be 83° 30', which is much smaller than the results obtained by Des Cloiseaux with prehnite from other localities. The plane of the optic axes bisects the obtuse angle between the cleavages. The prismatic cleavage is very perfect, hardly less so than the basal. No evidence of twinning like that noticed by Des Cloiseaux⁴ in some specimens, or that found by Professor Emerson⁵ in the prehnite of the Deerfield dike, was observed.

The only section of rock from the region under consideration in which

¹ Mémoires sur les Caractères minéralogiques et stratigraphiques des Roches dites Plutoniques de la Belgique et de l'Ardenne française. Mém. Couronnés de l'Acad. Roy. de Belgique, XL. 50, 74.

² Quart. Journ. Geol. Society, XL. 640.

³ Cf. Judd, On the Relations between the Solution Planes of Crystals and those of Secondary Twinning. Min. Mag., December, 1886.

⁴ Manuel de Minéralogie, p. 430.

⁵ Am. Journ. Sci., (1882,) XXIV. 270.

prehnite was discerned is No. 215 (Bell Rock, Malden) where it was found filling a minute fissure vein. The chalcodite which Professor Wadsworth has described was not noticed in any of the slides, and it seems certain that the important part which he assigned it, of completely taking the place of both feldspar and augite, is wrong.

A typical and unusually fresh specimen of the diabase (No. 222, Pine Hill, Medford) has been subjected to a quantitative chemical analysis by R. C. Sweetser, B. S., Assistant in Chemistry at the Worcester Polytechnic Institute, to whom I would here express my great obligation. Though fully engaged with other duties, he kindly offered to do the work and obtained the results given below in column I. Column II. contains the results of an analysis of a diabase from the Lenneschiefer at Büchtenbeck by Schenck, which shows considerable more decomposition, but is otherwise nearly identical.¹ Column III. is an analysis of diabase by Teall from Cauldron Snout, Durham, in the Whin Sill.²

	I.	II.	III.
SiO ₂	48.75	48.42	51.22
Al ₂ O ₃	17.97	17.59	14.06
Fe ₂ O ₃	0.41	1.05	4.32
FeO	13.62	8.36	8.73
CaO	8.82	7.73	8.33
MgO	3.39	4.30	4.42
MnO	0.91	—	0.16
K ₂ O	2.40	3.07	1.25
Na ₂ O	1.63	5.15	2.55
H ₂ O	0.60	2.24	1.28
TiO ₂	0.99	2.23	2.42
P ₂ O ₅	0.68	0.28	0.25
CO ₂	tr.	0.08	0.19
FeS ₂	tr.	0.15	0.49
	<hr/> 100.17	<hr/> 100.65	<hr/> 99.67
Sp. Gr.	2.935	2.919	

Schenck considered orthoclase as probably present in II. The analysis as well as the extinction angle shows the feldspar to be more acid than that of I. Augite is changed to viridite, and ilmenite occurs and alters to leucoxene along the *Gleitflächen*. The rocks I. and II. are thus shown to be very similar. The mineral composition as well as the chemical composition of III. is also nearly identical with that of I.

¹ Adolf Schenck. Die Diabase des oberen Ruhrthals und ihre Contacterscheinungen mit dem Lenneschiefer. Diss., Bonn, 1884, p. 20.

² Teall. Quart. Journ. Geol. Soc., XL. 640.

Augite Diorite.—This rock, though quite similar to the diabase, differs from it in a loss of the ophitic structure, and in the appearance of brown (basaltic) hornblende as the principal non-feldspathic constituent. In some sections augite does not appear, owing to complete uralitization. At other localities it comes into prominence, and there the rock may be known either as a diorite or a diabase.

The hornblende is for the most part the massive brown variety, which is well characterized by its color, perfect cleavage, large optical angle, and strong pleochroism. The absorption may be written $c = b \gg a$. The sections have in general distinct outlines parallel to the fundamental prism and the clino-pinacoid. A common feature of the hornblende crystals is the occurrence within them of cores of augite, which seem to show either that the hornblende is derived from the augite by pseudomorphism, or that the two minerals crystallized originally in their present relations. Such pseudomorphism was first noticed by Streng¹ in 1877, and subsequently by Hawes,² Irving,³ Van Hise,⁴ Sjögren,⁵ and Von Lasaulx.⁶ Remarkable instances of this change have been described by Professor Williams,⁷ from the Cortlandt Series on the Hudson River, and by Schenck,⁸ from the diabase of the Upper Ruhrthal in Westphalia. The former has shown the gradual passing of the augite into brown hornblende. The latter has described a further change of the brown to green hornblende, while Von Lasaulx found in the diabase of Kürenz that the change of the augite was first to uralite, then to brown hornblende. In the diorite which we are considering, the contact of augite and hornblende is a sharp line. No evidence of a gradation from one mineral to the other was anywhere observable. The hornblende is in general very fresh, while the augite alters readily to chlorite, so that in many cases only a few scattered fragments of augite can be seen (Figure 2). It seems probable, therefore, that these combinations are the result of parallel growth. Teall⁹ has figured such growths in the Whin Sill, and Rohrbach¹⁰

¹ A. Streng. Neues Jahrbuch für Mineralogie, etc., 1877, p. 133.

² G. W. Hawes. Mineralogy and Lithology of New Hampshire, pp. 57, 206, Plate VII. Fig. 1.

³ R. D. Irving. Geology of Wisconsin, III. 170.

⁴ C. R. Van Hise. Am. Journ. Sci. [3], XXVI. 29.

⁵ H. Sjögren. Neues Jahrbuch für Mineralogie, etc., 1884, I. 82 (Ref.).

⁶ A. v. Lasaulx. Verh. d. Naturh. Vereins d. pr. Rheinl. u. Westf., 1878, p. 171.

⁷ G. H. Williams. Am. Journ. Sci. [3], XXVIII. 259.

⁸ A. Schenck. Die Diabase des oberen Ruhrthals, etc. Diss., Bonn, 1884.

⁹ Quart. Journ. Geol. Soc., XL. 653, Plate XXIX. Fig. 3.

¹⁰ Min. u. petr. Mitth., VII. 1, Plate I. Figs. 1-7, 1886.

in the Cretaceous formation of Silicia. The figures of the latter show a sharp line of contact between the two minerals. He was also able to show that, in the majority of cases at least, the minerals were in parallel position. Chemical analysis showed an essential difference in the composition of the augite and hornblende. It was also observed that decomposition had seldom progressed to the same point in both minerals when together, though neither seemed to offer in all cases more resistance to decomposition than the other.

A remarkable instance of mechanical deformation is exhibited in section No. 202. A large crystal of brown hornblende has been bent until it has the shape of a letter S. The optical properties are anomalous, as would be expected, and a crystal of apatite has been bent about the hornblende crystal, which has been attended with crushing, and optical disturbances, so that the apatite crystal is extinguished in a mosaic. This must be referred, however, to motions which existed in the partially consolidated magma, as we would expect to find anomalies in the optical behavior of the plagioclase grains if it were due to the action of orographic forces.

Section No. 208 (corner Elm and Morrison Streets) is porphyritic, the base being difficult to resolve. The porphyritic crystals are feldspar and parallel growths of augite and hornblende.

The chlorite of No. 202 is often filled with belonites of a green color, arranged in three parallel directions, cutting each other very precisely at angles of 60° .

Summary and Conclusions.

What has been noted in the preceding pages may be summed up in the following statements.

The dike under consideration includes, not only the exposures of so-called "diorite," but outcrops, in the vicinity of the Old Powder House in Somerville, of rock intermediate in texture between the normal "diorite" and normal "greenstone," as well as the "greenstone" itself. The coarseness of texture is in general dependent only on the position of the specimen in the dike, the fine-grained rock being naturally found near the contact. The general composition of the rock is that of a diabase, though facies of augite-diorite occur.

The diabase has in general a more or less ophitic structure, and is characterized by the original constituents, plagioclase, augite, biotite, apatite, ilmenite, and magnetite; apatite and the ore minerals comprising

the first generation, while feldspar, augite, and biotite crystallized nearly contemporaneously and form the second generation. The secondary minerals are uralite, chlorite, biotite (in part?), leucoxene, kaolin (?), magnetite (in part), calcite, pyrite, and quartz. The plagioclase is somewhat variable in composition, owing to zonal structure, but has probably an average composition corresponding to andesine. It is also probable that orthoclase is present, though the potash obtained in the analyses may be derived from a plagioclase containing a considerable per cent. of potassium. The augite-diorite differs from the diabase in that the ophitic structure is wanting, and that the brown hornblende, which now comes into greater prominence than the augite, is generally in idiomorphous crystals. The diorite is characterized by very perfect instances of the parallel intergrowth of augite and hornblende.

In both the diabase and diorite the change of the augite has been uralitization, though in the diorite it has in many cases changed directly to chlorite.

In conclusion, I have to acknowledge obligation to my instructors, Mr. J. E. Wolff, of Harvard University, and Dr. George Huntington Williams, of the Johns Hopkins University. The greater part of the microscopical examination in connection with this paper was made in the laboratory of Mr. Wolff, and I am indebted to him for much advice and suggestion. Dr. Williams has examined most of the slides, and assisted me in countless ways in the preparation of this paper. I am also much indebted to Mr. R. C. Sweetser, of the Worcester Polytechnic Institute, for a complete chemical analysis.

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EXPLANATION OF PLATE.

- Fig. 1. Illustration of the change of hexagonal plates of biotite to chlorite, with separation of magnetite in concentric rims. From sections No. 202 and 203.
- Fig. 2. Illustration of the intergrowth of augite and brown hornblende, and alteration of the former to chlorite. The alteration of ilmenite to leucoxene along the *Gleitflächen* is also shown. From sections No. 202 and 208.